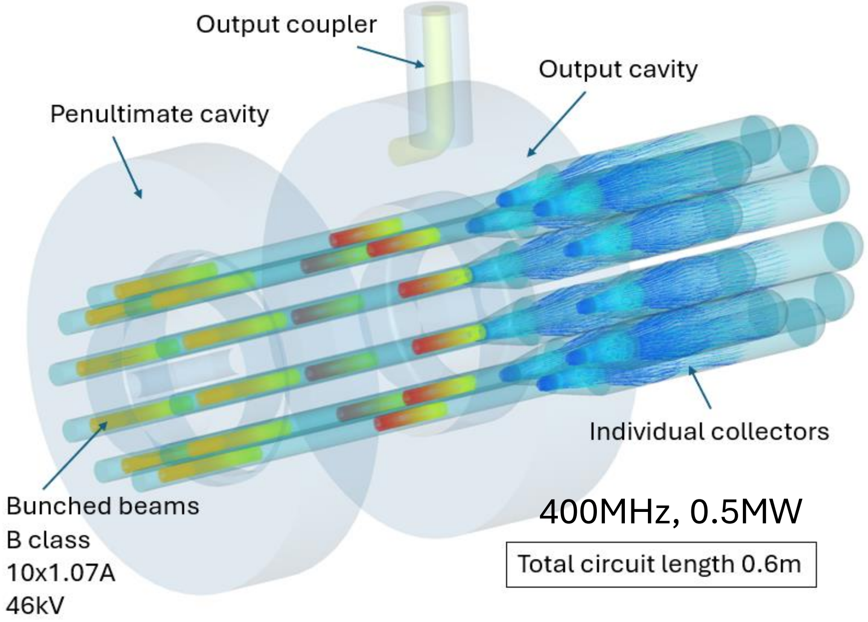
RF sources and efficiency

I. Syratchev

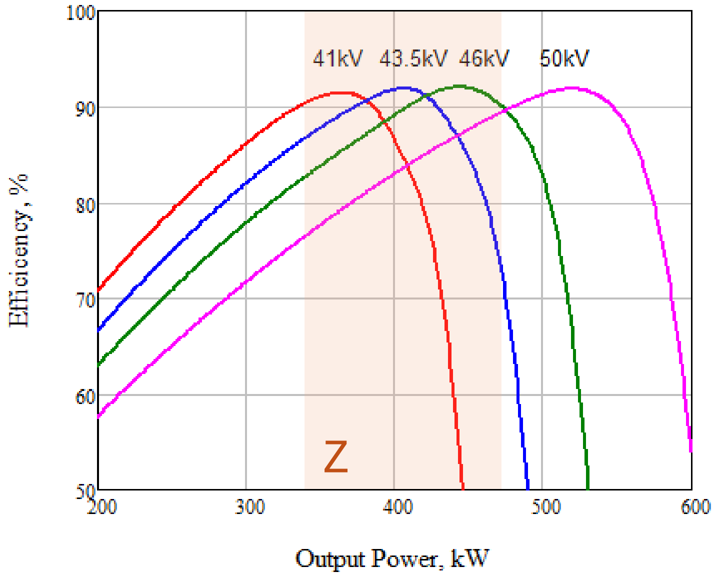
MB Tristron – a unique gridded tube for FCC_{ee} collider



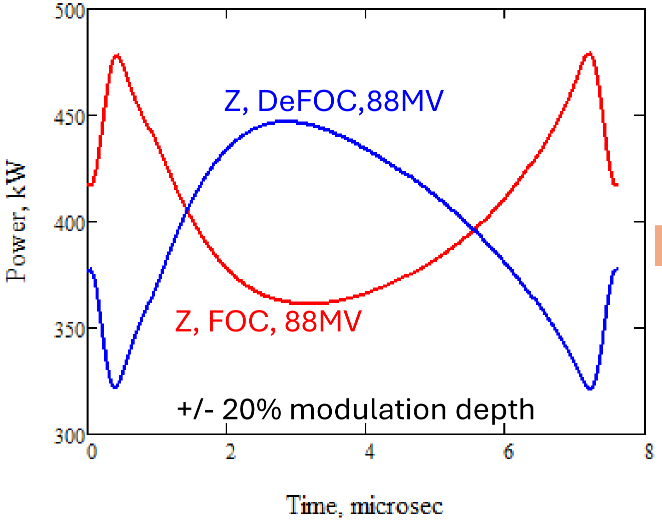
- Very efficient: >90%
- Low Voltage: <50kV
- Compact: ~ $1m^3$
- Cost effective (compared to klystron)
- No power consumption in sleeping mode (without RF)
- Low power in collector (<50kW) and solenoid (3kW)

More reading: https://indico.cern.ch/event/1449294/

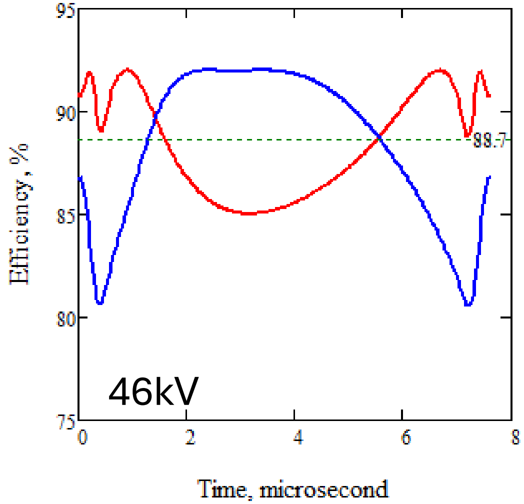
Tristron Efficiency vs. P out for different HV



Cavities RF power modulation, 88MV

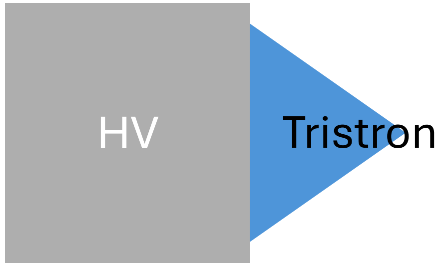


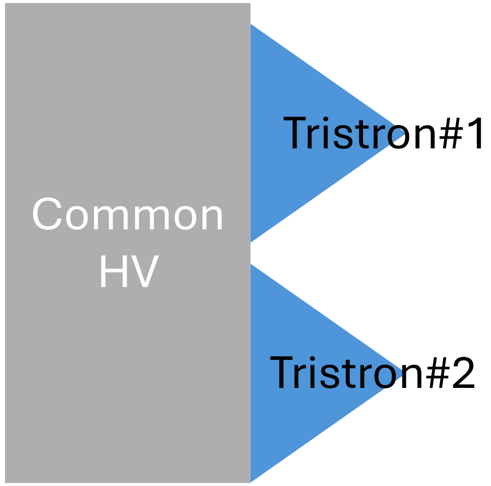
Tristron transient efficiency



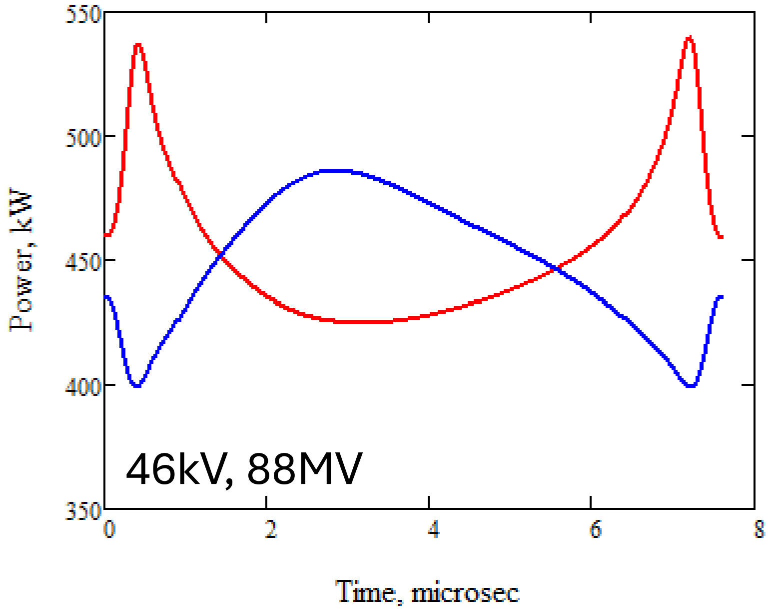
For the required RF power modulation feedback (by LLRF only), the HV set point can be selected so that average efficiency will stay ultimately high: 88.7% (Z) and 91% (W,H). With HE TS klystron average efficiency will stay at 67% (Z).

Issues with transient loading of the HV power supply



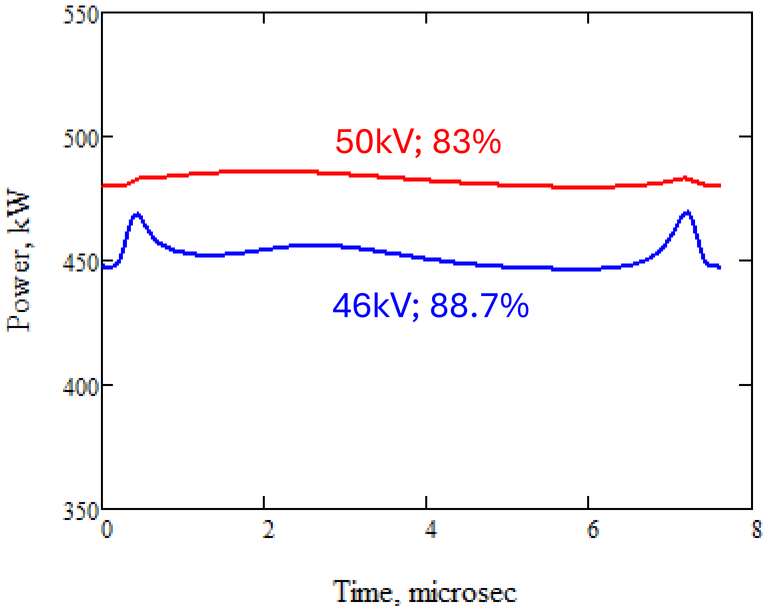


Transient power drain from HV power supply



It will be hard to provide such a bandwidth in HV unit.

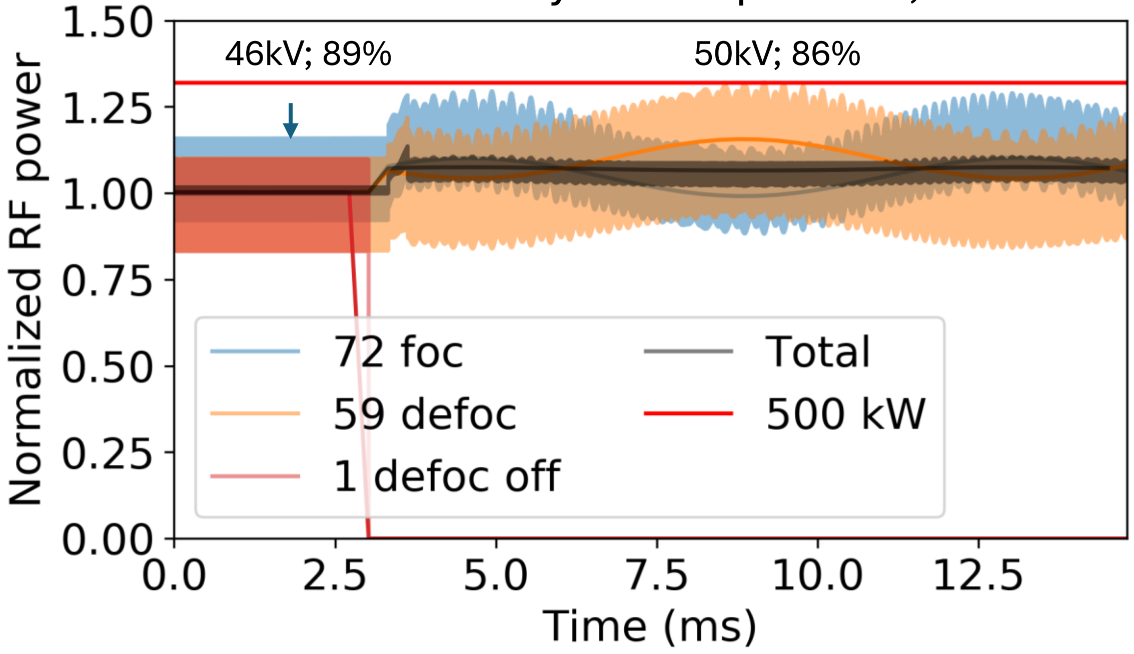
Transient power/2 drain from common HV power supply



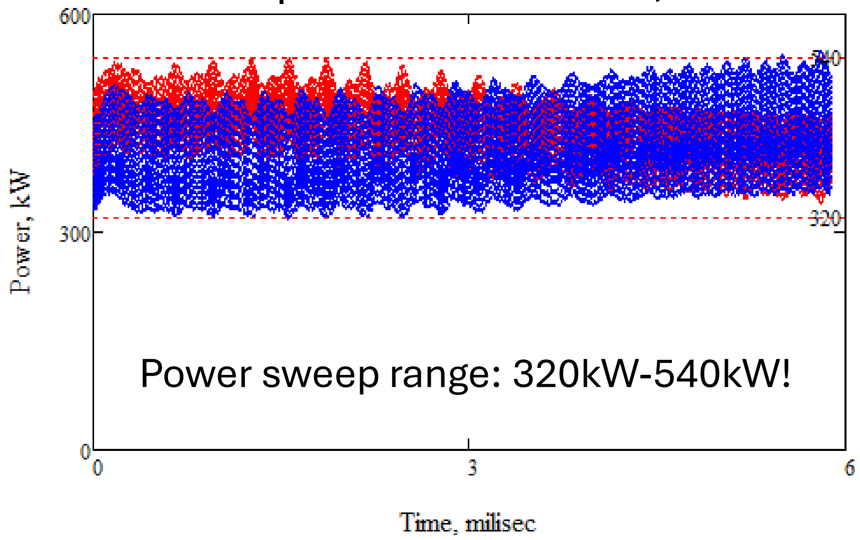
With this layout we can set HV point and negotiate modulator bandwidth vs. average efficiency.

Failure mode mitigation

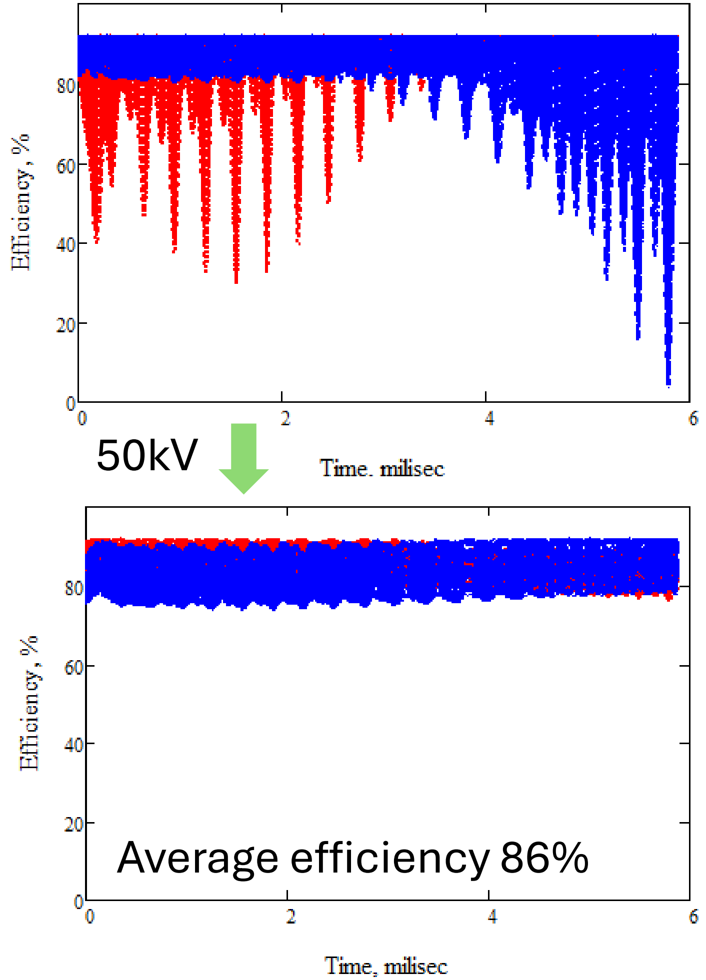
One cavity out of operation;103MV



RF power modulation; 88MV



46V Tristron transient efficiency



Working scenario: in the case of failure, slow (200-300 μsec) ramp up of the tristron modulator voltage from 46kV to ~50kV will provide efficient operation in the failure mode.

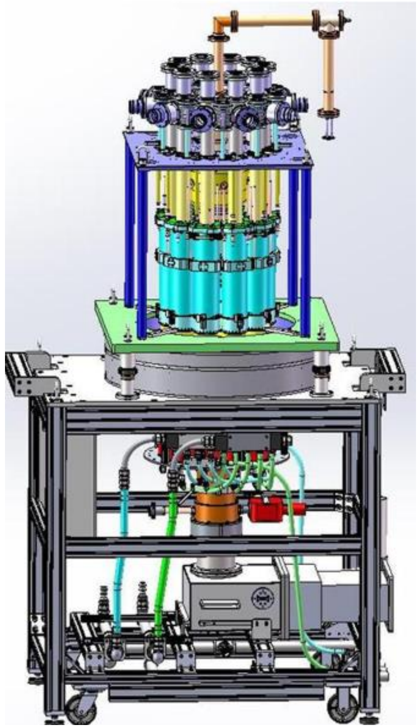
Tristron for FCC_{ee}. Implementation scenarios.

Technology demonstrator (low cost at short time): Retrofit upgrade of existing ESS 0.7GHz, 1.2 MW MB IOT, anticipating efficiency increase from 70% to ~85%.

- Full recycling of the exiting components (gridded cavity, output cavity and collector).
- RF circuit and optics design and optimization at CERN.
- Tube refurbishment at Thales – introducing extra cavity and compact external solenoid.
- Testing at ESS using existing facilities.
- Estimated schedule is about **18 month**.

** Potential candidate for the graceful replacement of ESS klystrons along accelerator life-time.*

*** Frequency is close to 800MHz needed for FCC.*



FCC_{ee} 0.5 MW Tristron prototype at 400MHz.

- RF circuit and optics design and optimization at CERN.
- Common input cavity vs. clustered option design and cost optimization (Thales+ ? + CERN)
- Tube fabrication at Thales+?.
- Estimated schedule is about **36 month**.